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April 9, 2015

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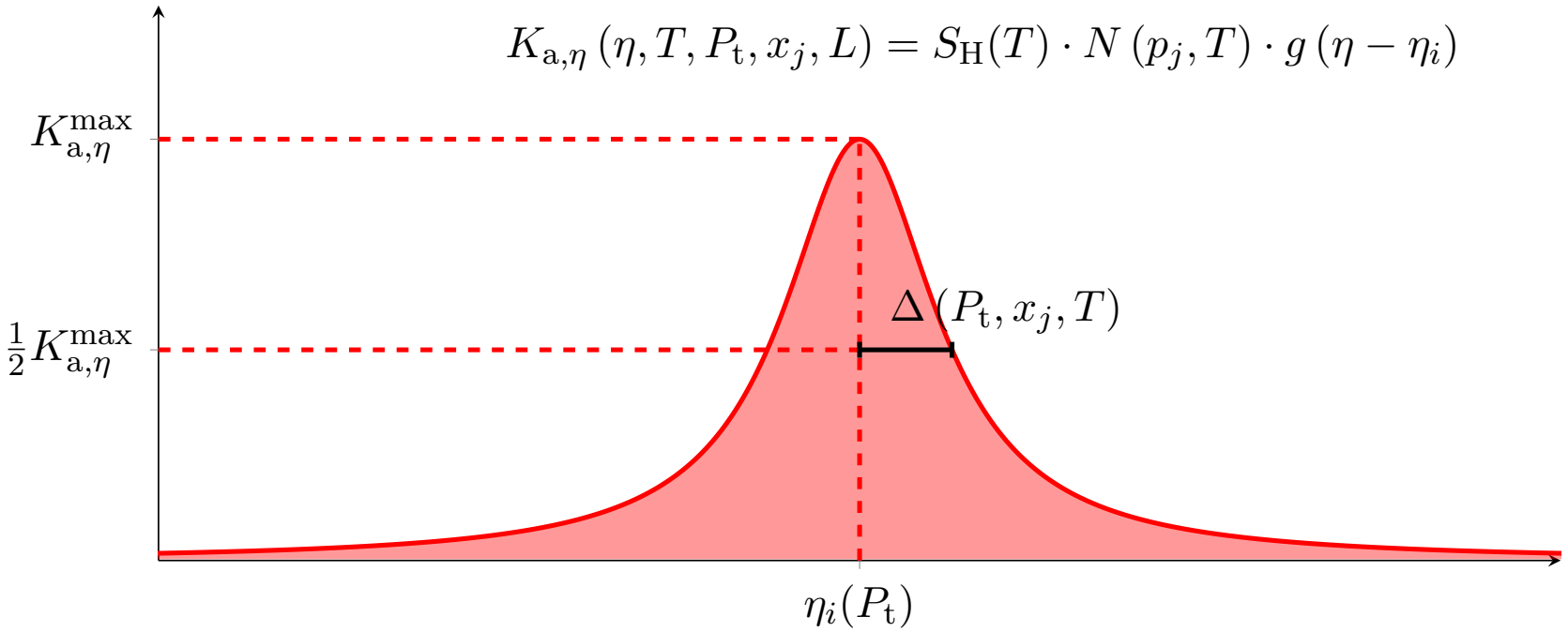
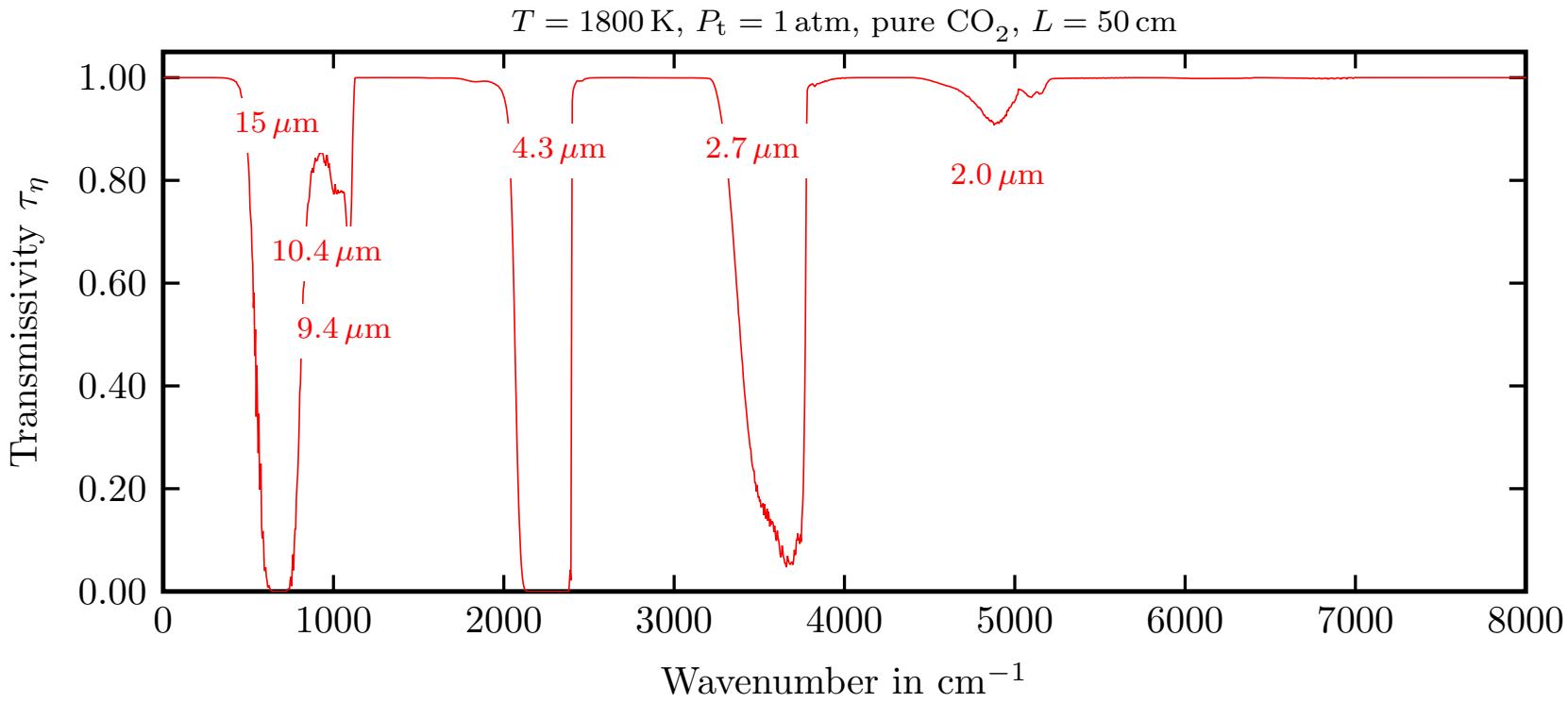
Line-by-Line Method



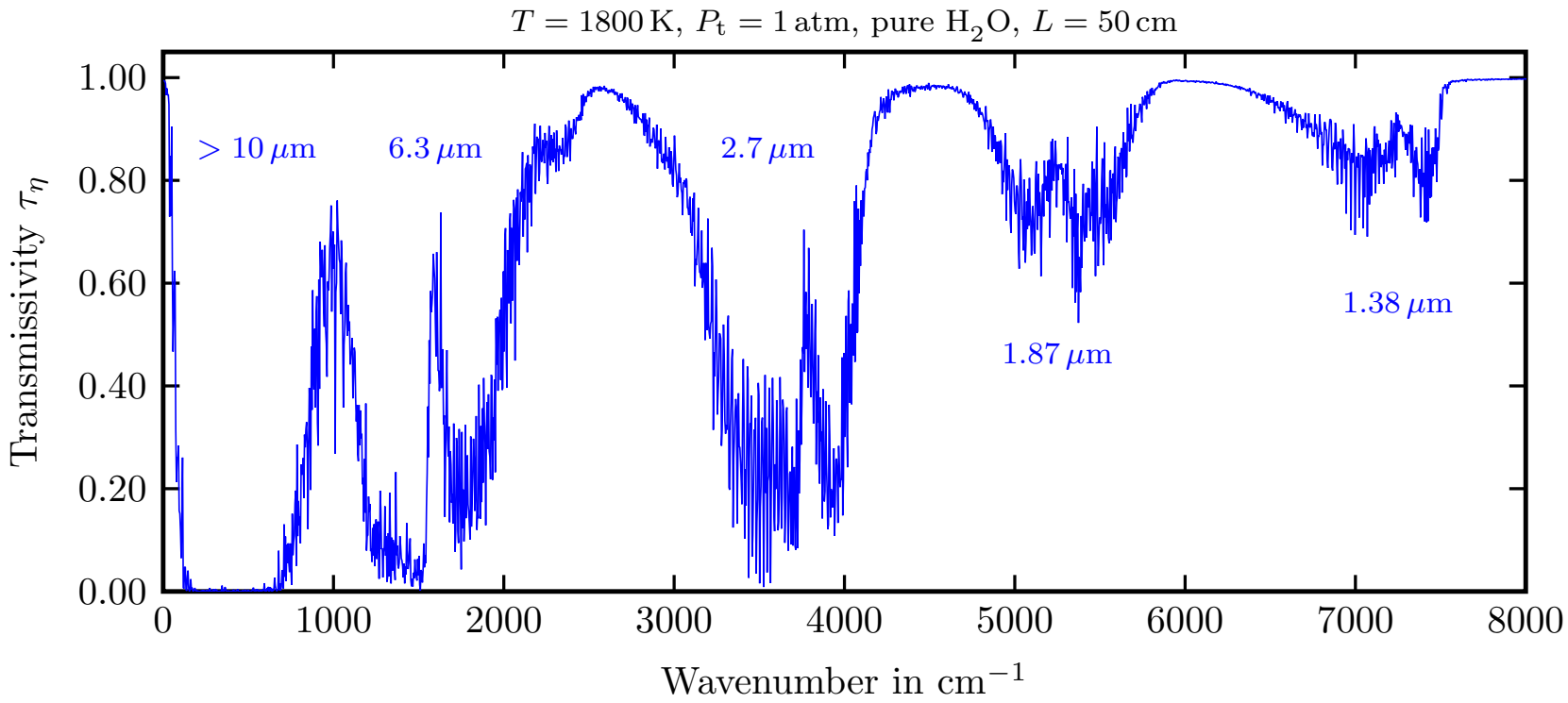
- 7 Parameter for each line are needed from Spectral database
- Equation of state: Ideal gas law
- Lineshape: Lorentz
- $a_\eta = \sum_{\text{all lines}} K_{\mathrm{a},\eta}$

Line-by-Line Method



$$\tau_\eta = \exp\left(-a_\eta \cdot L\right) \qquad \varepsilon_\eta = 1 - \tau_\eta$$

Line-by-Line Method



$$\varepsilon^{\mathsf{tot}} = \frac{1}{\sigma \cdot T^4} \cdot \int_0^\infty \varepsilon_\eta \cdot \frac{c_1 \cdot \eta^3}{\exp\left(\frac{c_2 \cdot \eta}{T}\right) - 1} \cdot \mathrm{d}\,\eta$$

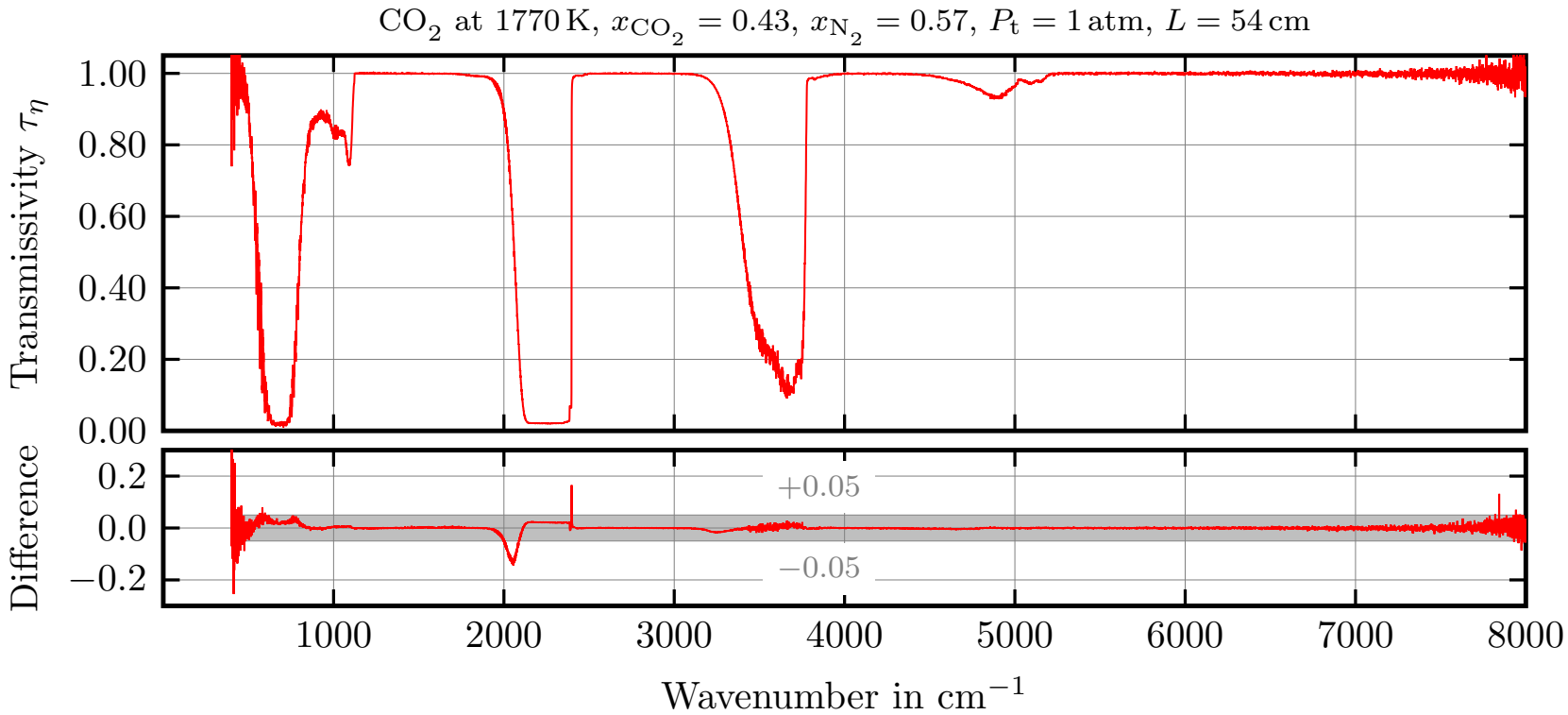
Content of this Chapter

High Temperature

Important Measurements (without any claim to completeness)

- Modest & Bharadwaj (2002-2007) [5, 6, 10]
  - up to 1550 K, CDSD-1000 and HITEMP-1995, 4 cm^{-1}
  - also compared with HITEMP-2010, see Alberti et. al. [1]
- Becher et. al. (2012) [4]
  - up to 1770 K, HITEMP-2010, Measurements performed at DTU, 32 cm^{-1}
- Alberti et. al. (2015) [3]
  - 22 cases, 500 - 1770 K, also mixtures, DTU, 1 cm^{-1}
  - whole spectral range from 450 to 7600 cm^{-1}

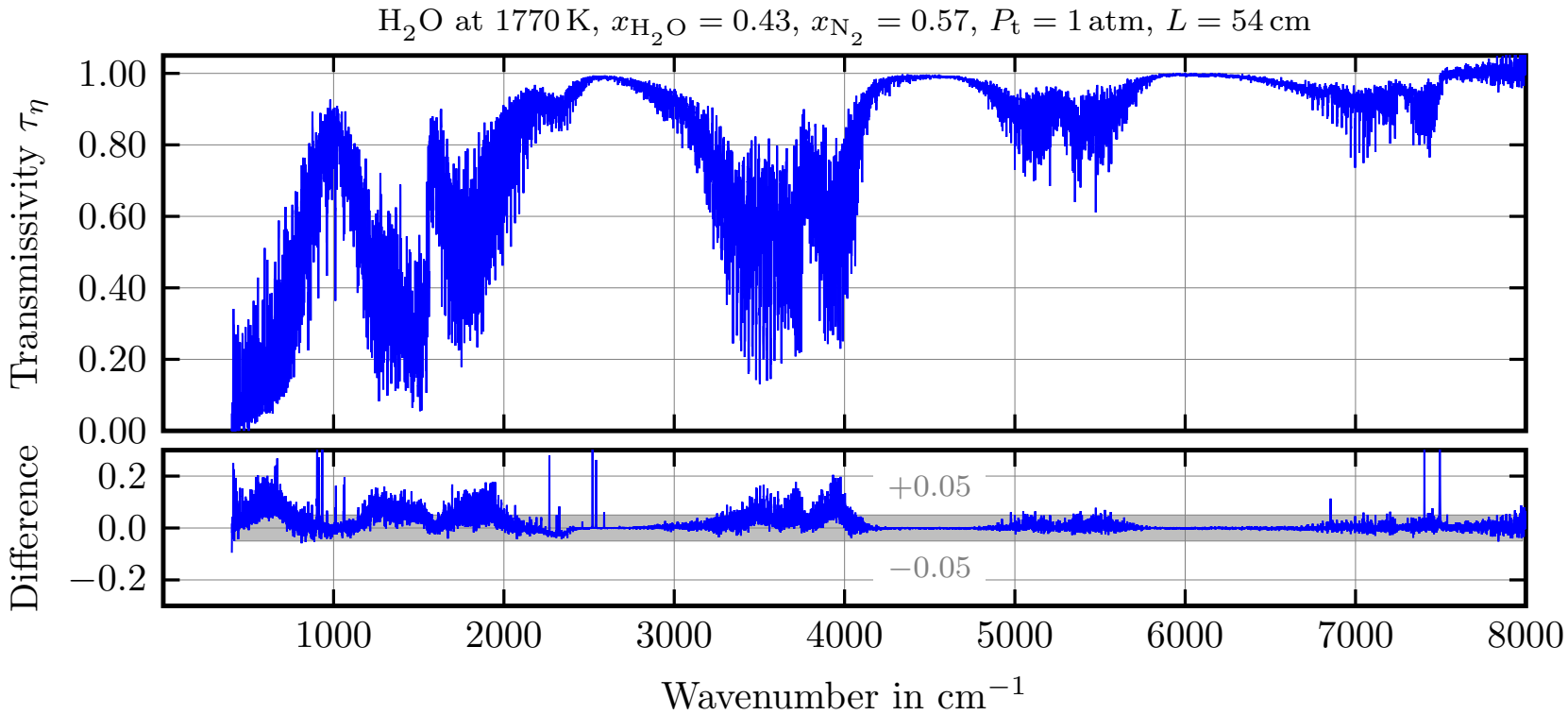
High Temperature - Alberti et. al. (2015)



$$\text{Difference} = \tau_{\eta,\text{Measured}} - \tau_{\eta,\text{HITEMP}-2010}$$

see Alberti et. al. [3]

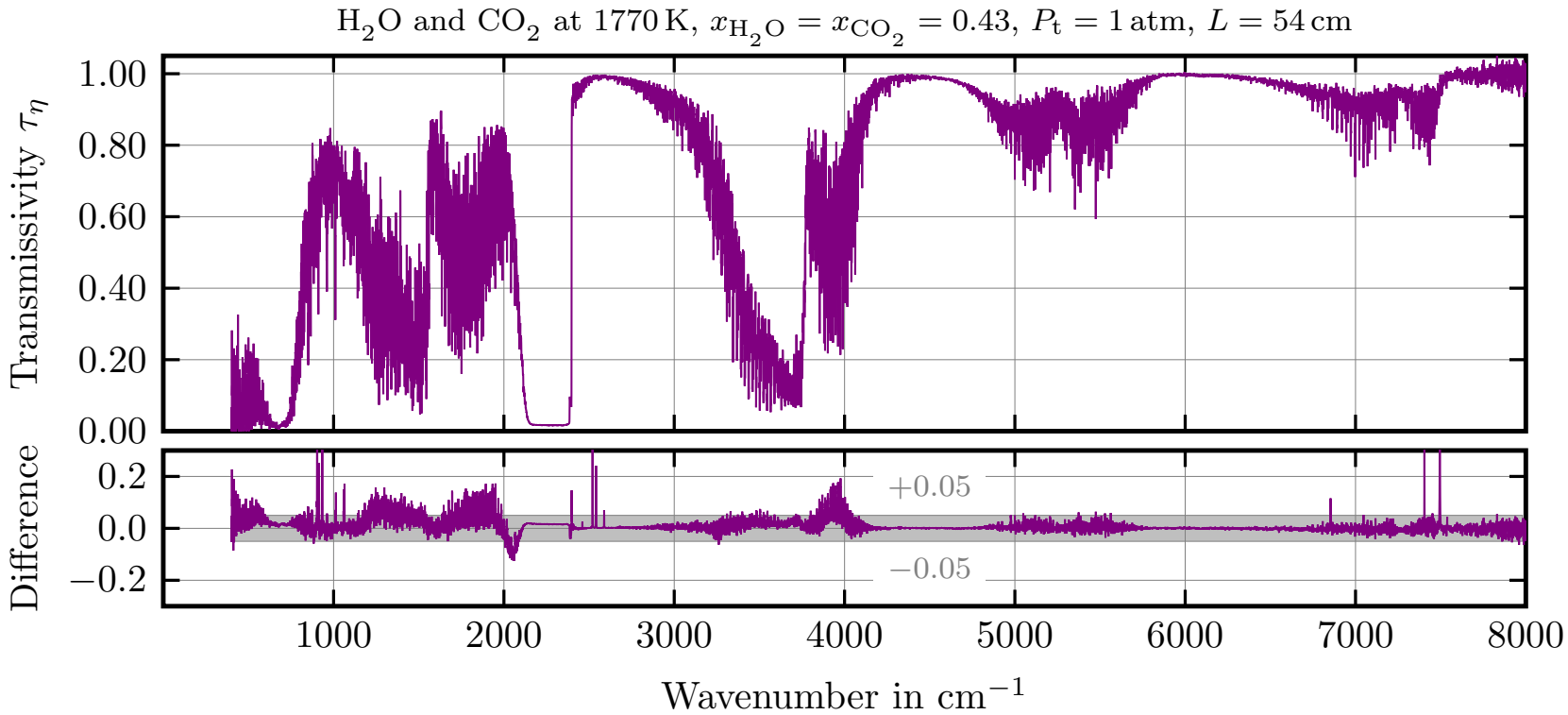
High Temperature - Alberti et. al. (2015)



$$\text{Difference} = \tau_{\eta,\text{Measured}} - \tau_{\eta,\text{HITEMP}-2010}$$

see Alberti et. al. [3]

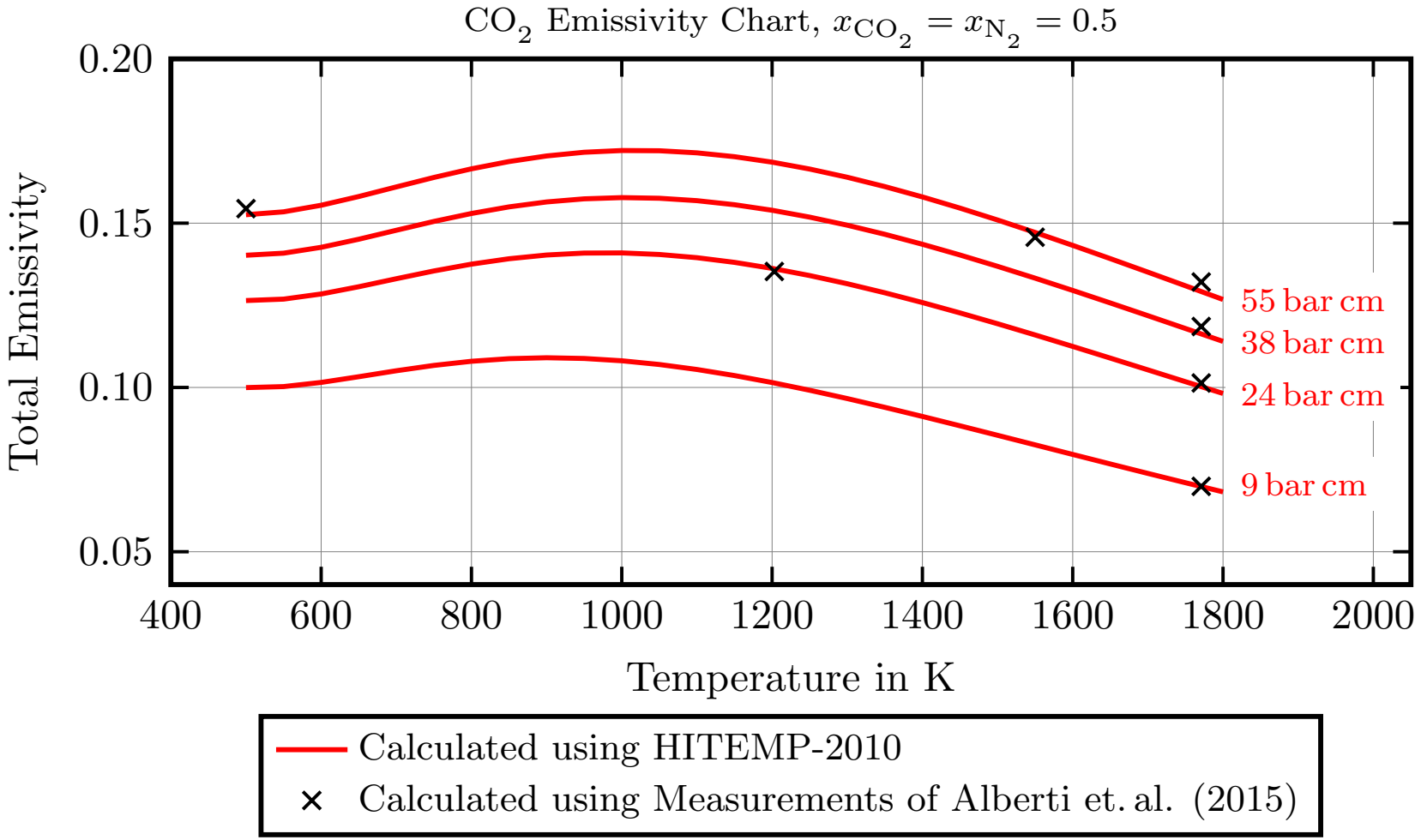
High Temperature - Alberti et. al. (2015)



$$\text{Difference} = \tau_{\eta,\text{Measured}} - \tau_{\eta,\text{HITEMP}-2010}$$

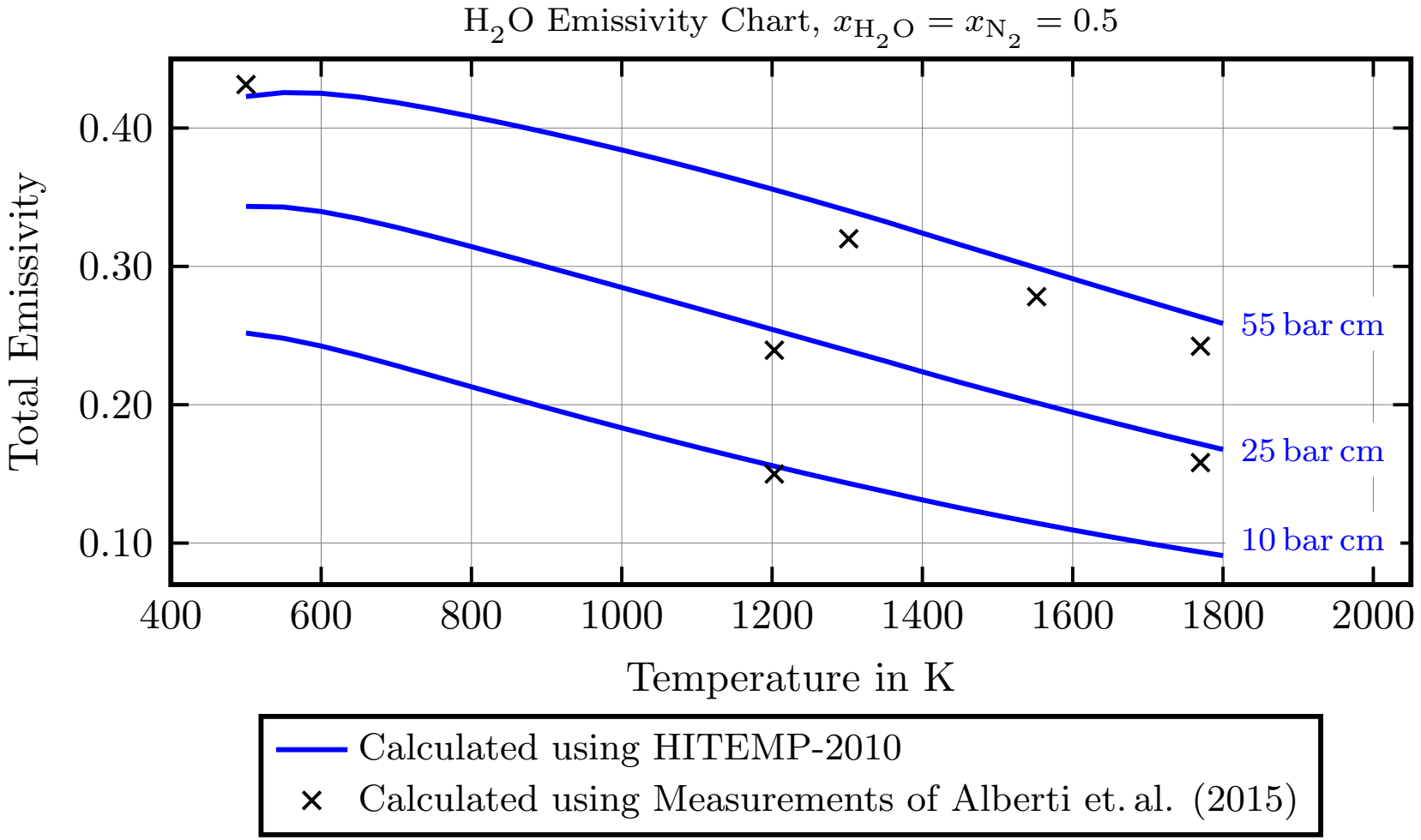
see Alberti et. al. [3]

High Temperature - Alberti et. al. (2015)



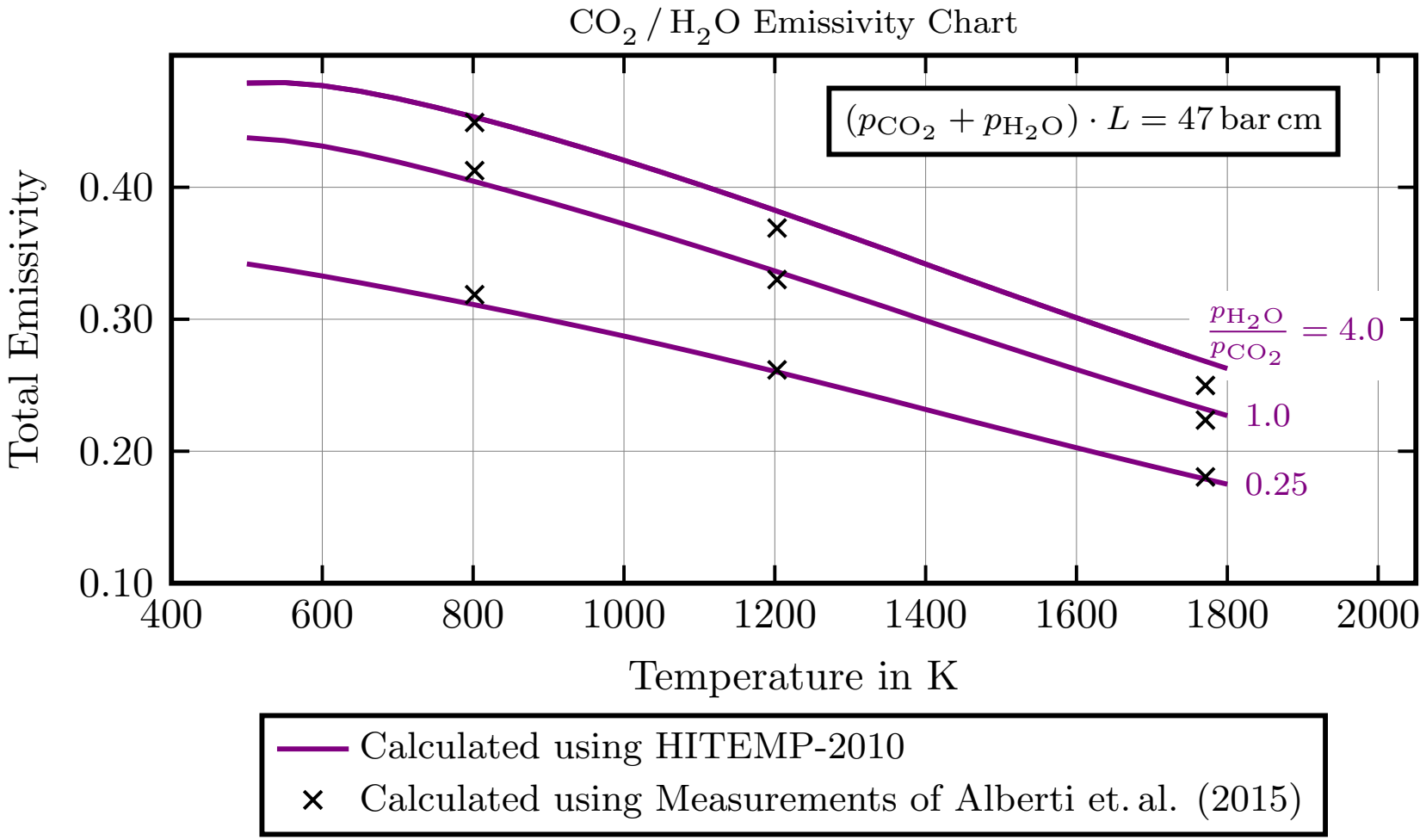
$$pL = p_{CO2} \cdot L$$

High Temperature - Alberti et. al. (2015)



$$pL = p_{H2O} \cdot L$$

High Temperature - Alberti et. al. (2015)



$$pL = (p_{CO2} + p_{H2O}) \cdot L$$

Content of this Chapter

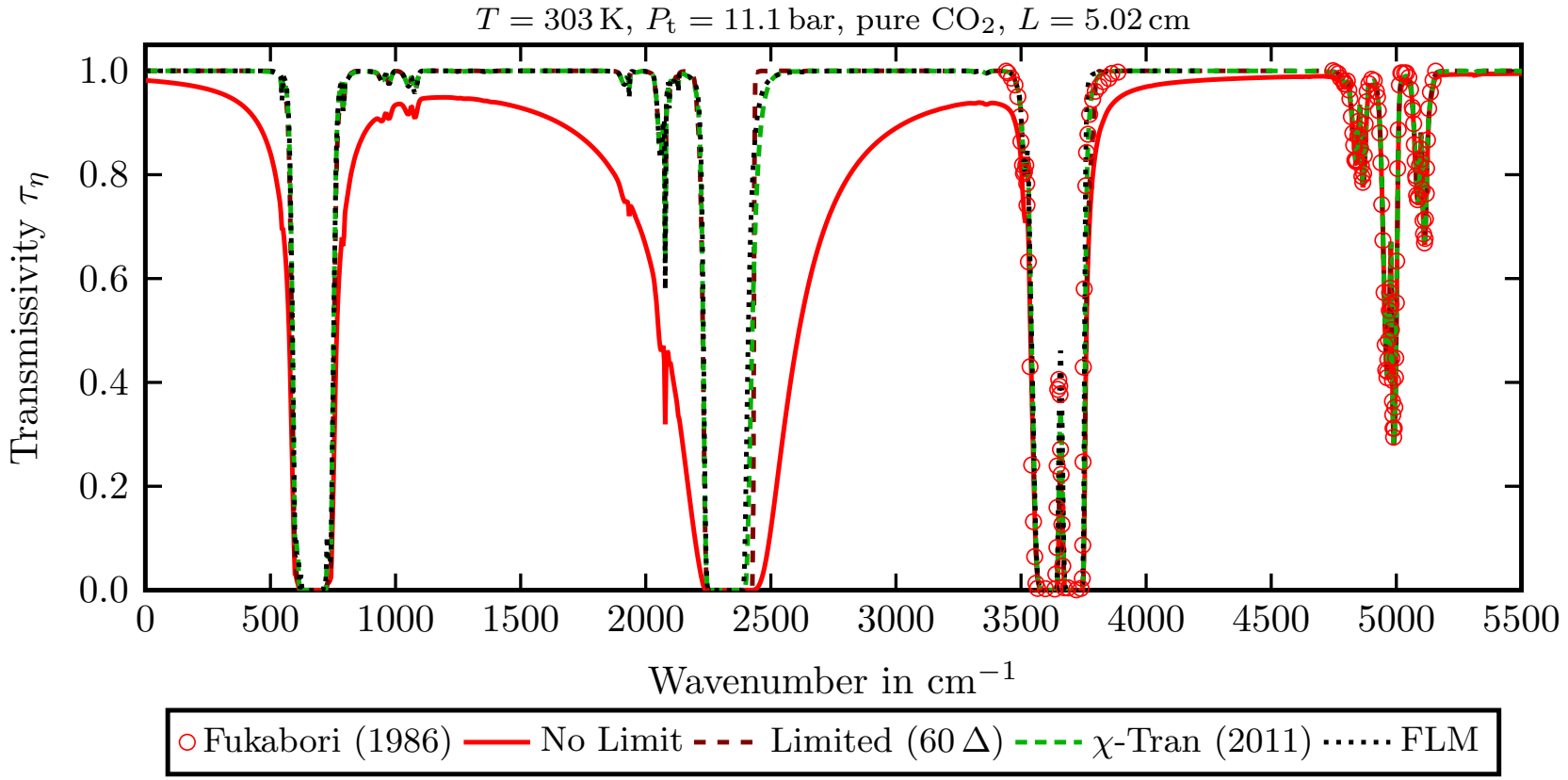
High Pressure

Important Results for CO_2 (without any claim to completeness)

- Measurements
  - Fukabori et. al. (1986) [7]
  - Hartmann and Perrin (1989) [8, 11]
  - Scutaru et. al. (1993) [12]
- Models / Adjustments
  - Full Line-Mixing software of Lamouroux [9]
  - χ-factors of Tran (2011) [13]
  - Cut-off criterion of Alberti et. al. (2015) [2]
    - Number Lorentz-half-widths

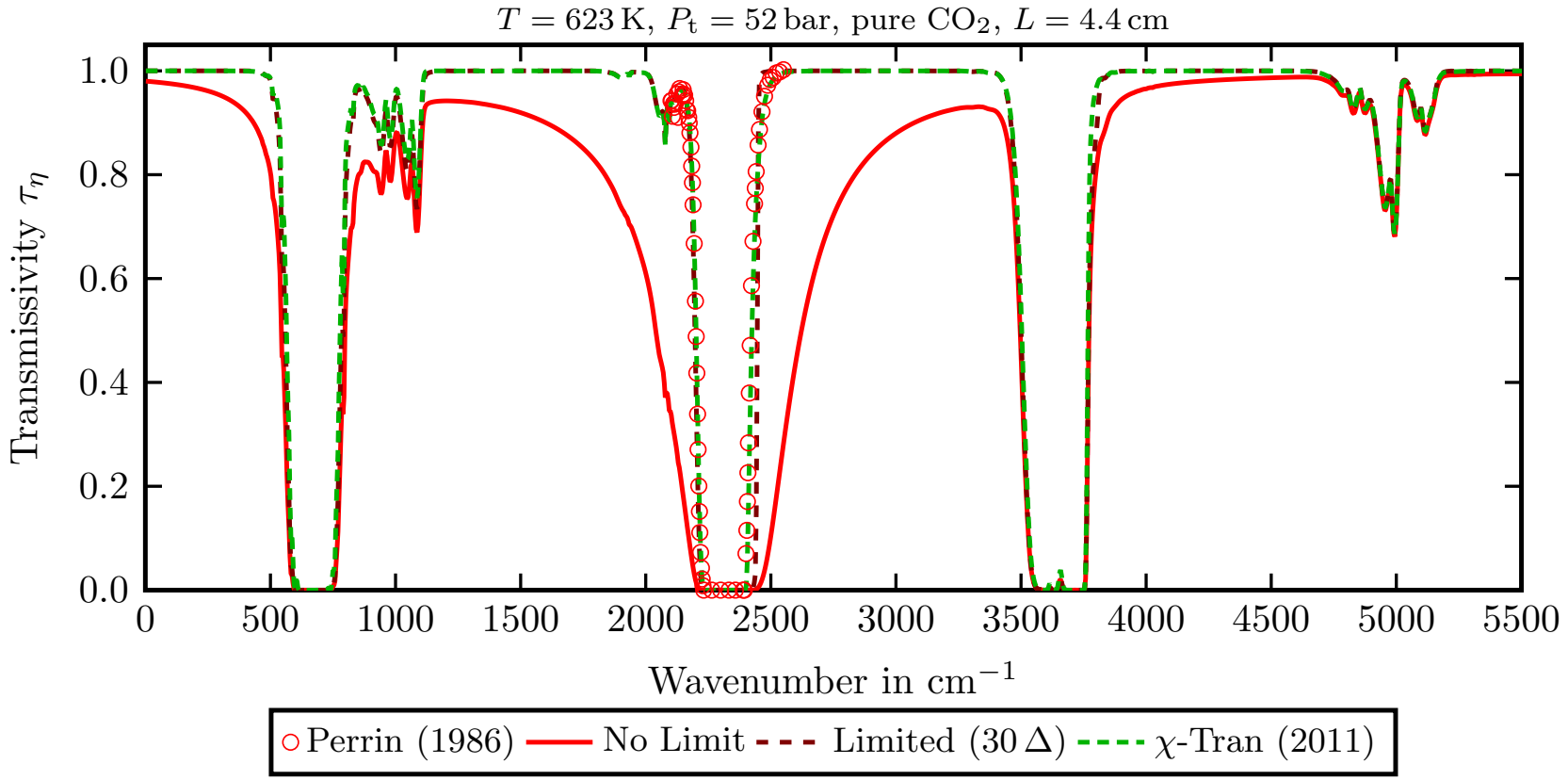
$$n(T, P_t) = 4.0 \cdot \left(\frac{T}{P_t}\right)^{0.822}$$

High Pressure - Alberti et. al. (2015)



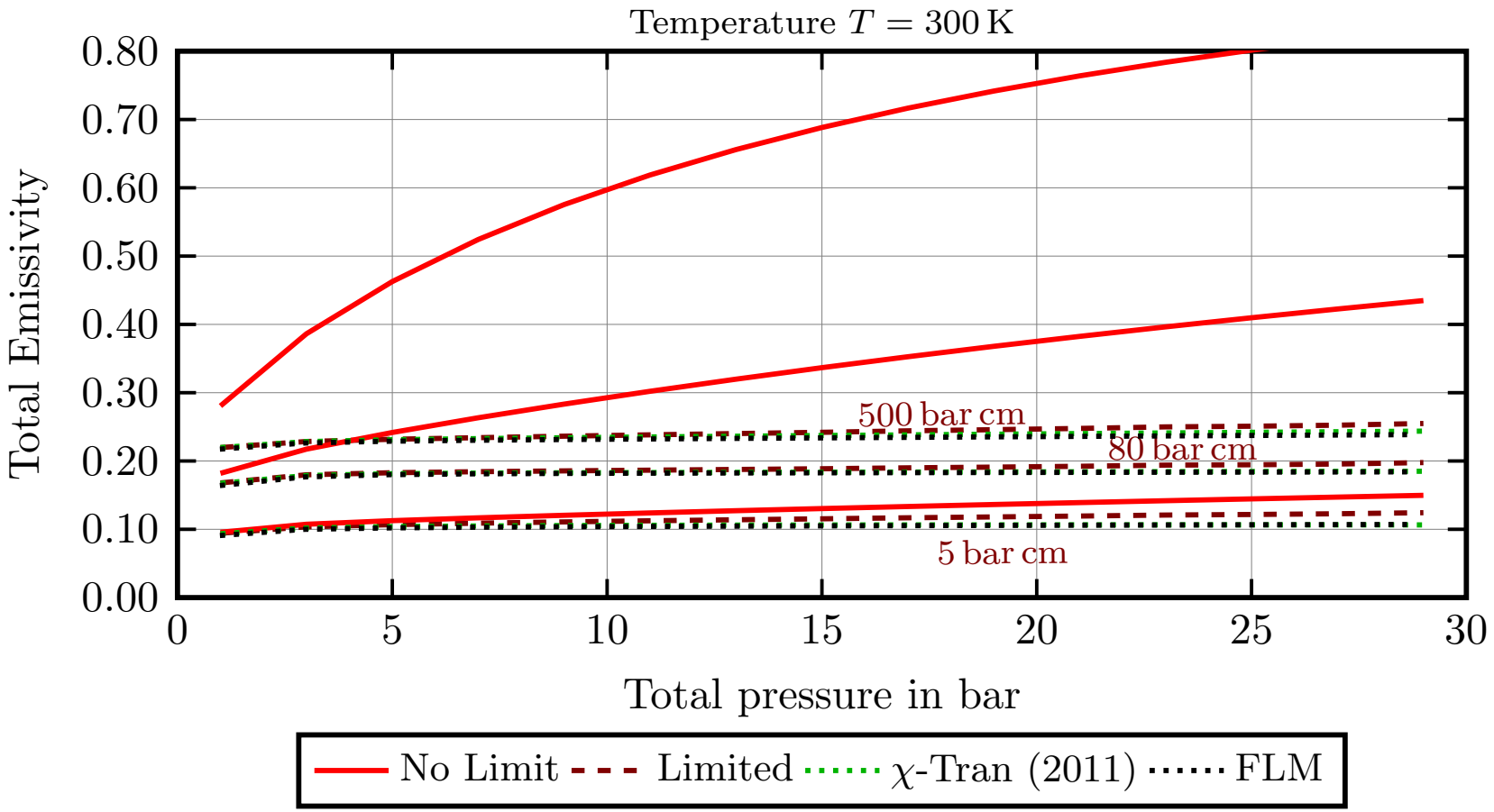
see also Ref. [2]

High Pressure - Alberti et. al. (2015)



see also Ref. [2]

High Pressure - Alberti et. al. (2015)



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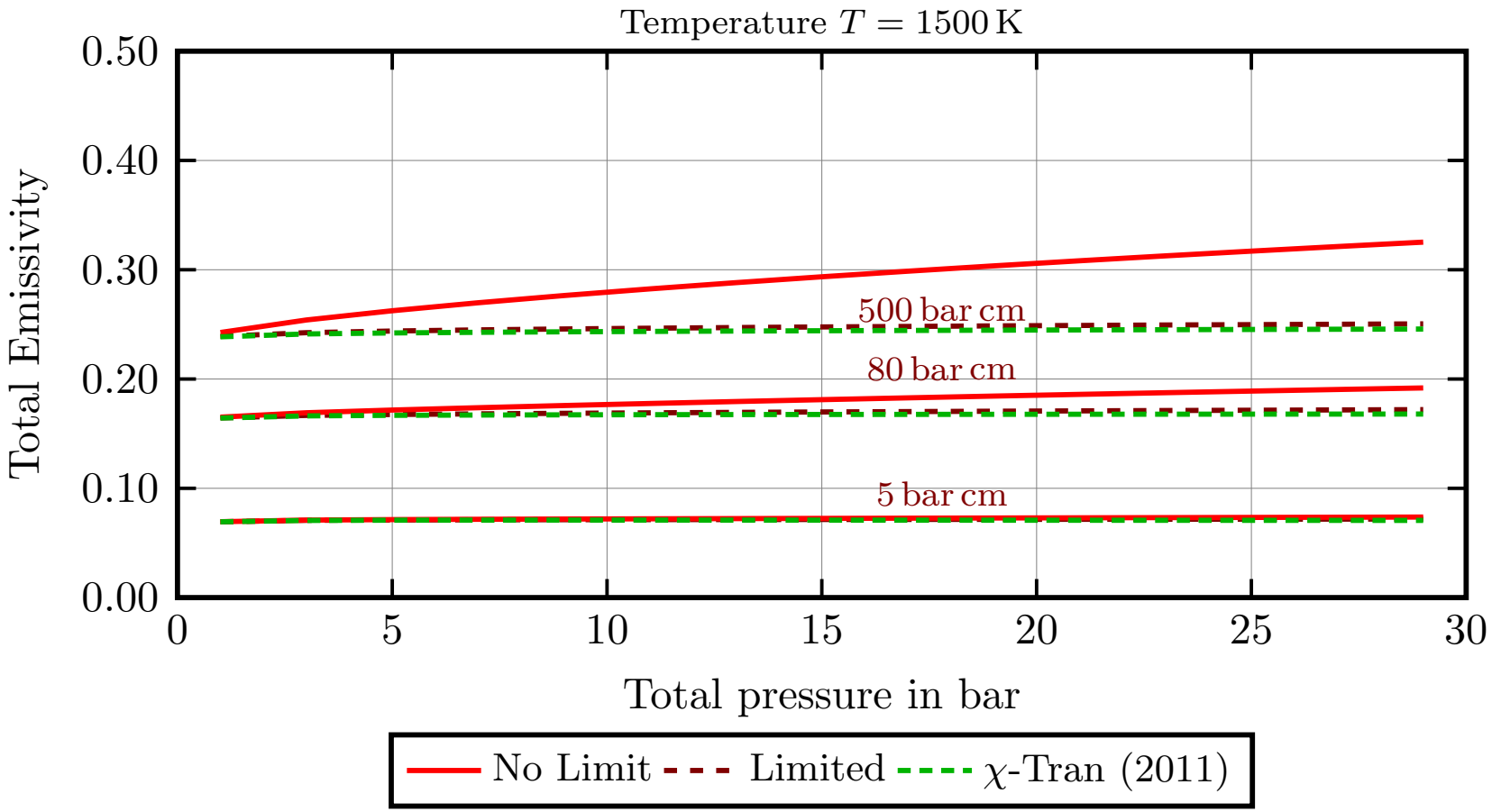
High Pressure - Alberti et. al. (2015)



see also Ref. [2]

Content of this Chapter

Summary and Conclusion

- High temperature and atmospheric pressures
  - CO_2: maximum 2 % difference (up to 1770 K)
  - H_2O: maximum 9 % difference (up to 1770 K)
  - $CO_2 + H_2O$: maximum 7 % difference (up to 1770 K)
- High pressure / density
  - Measurements for small spectral regions
  - New, full spectrum measurments are needed
  - Lineshape adjustment seems to be essential
- CO measurements for gasification applications

Acknowledgments

The authors gratefully acknowledge the financial support by the Helmholtz Association of German Research Centres (HGF) in the frame of the Helmholtz Virtual Institute for Gasification Technology - HVIGasTech (VH-VI-429).

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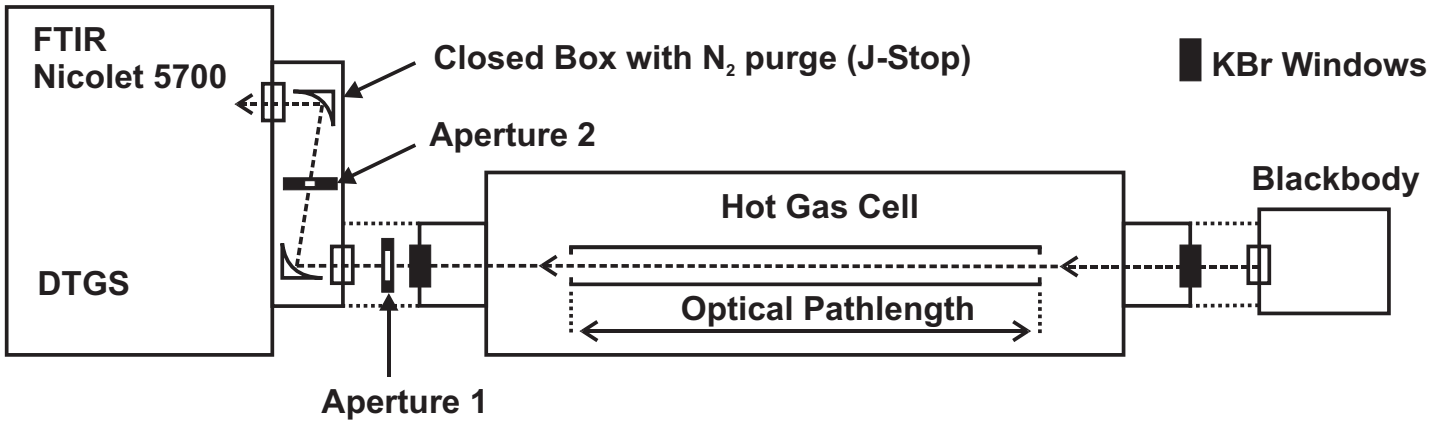
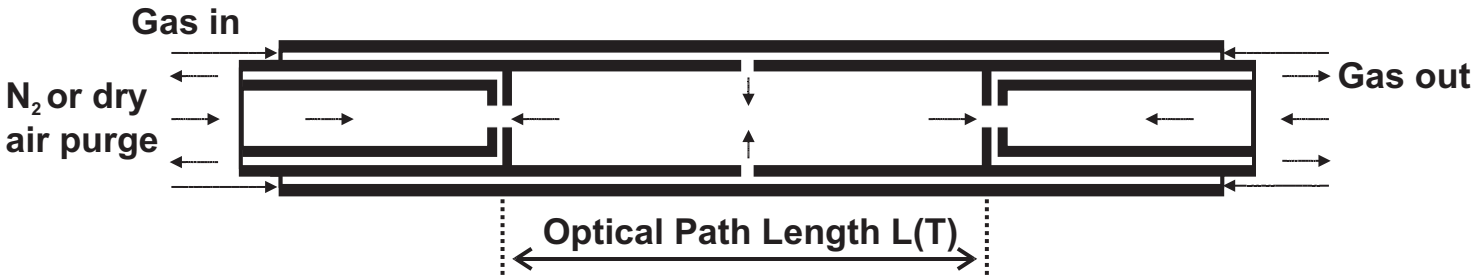
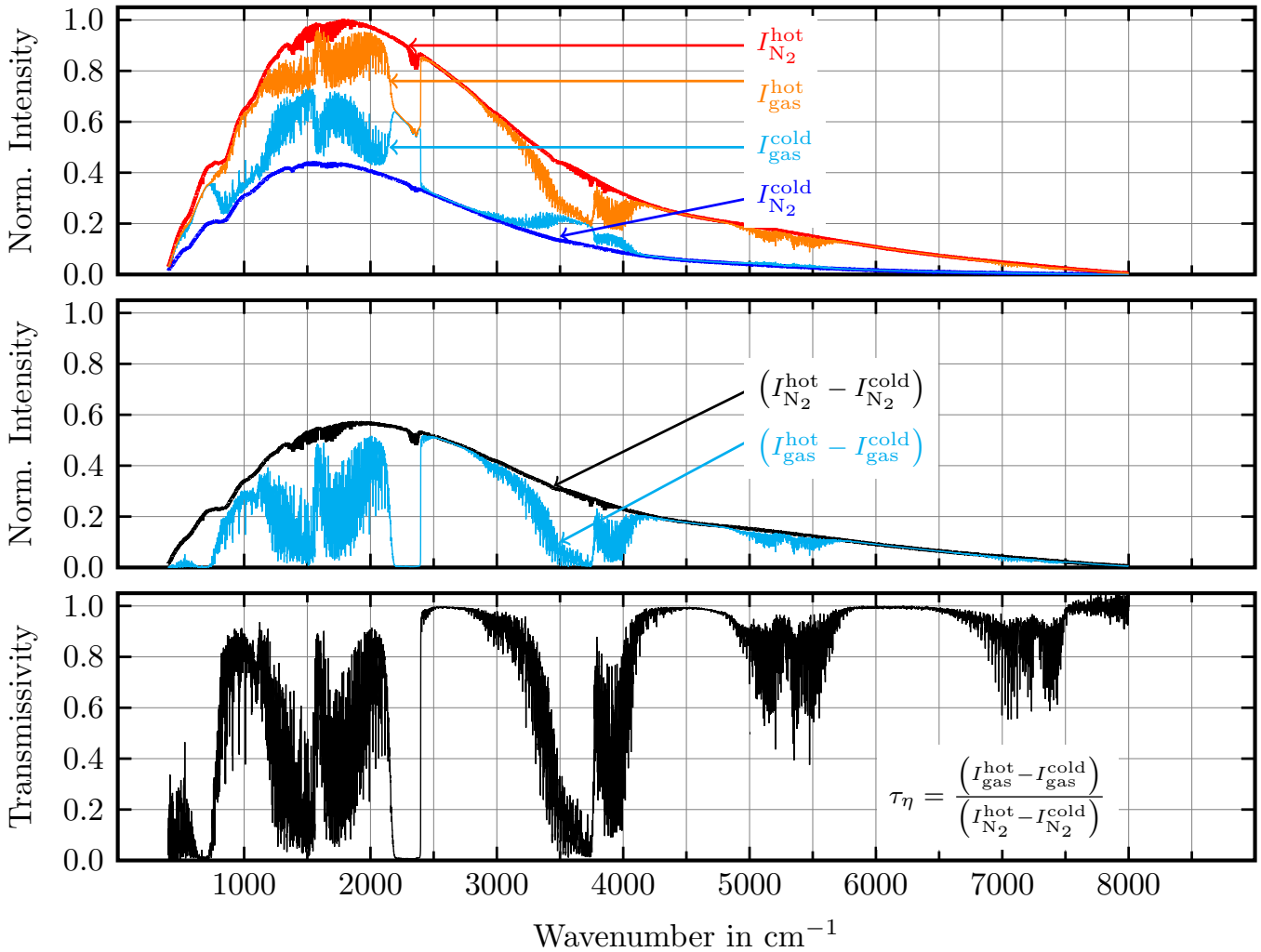
Appendix





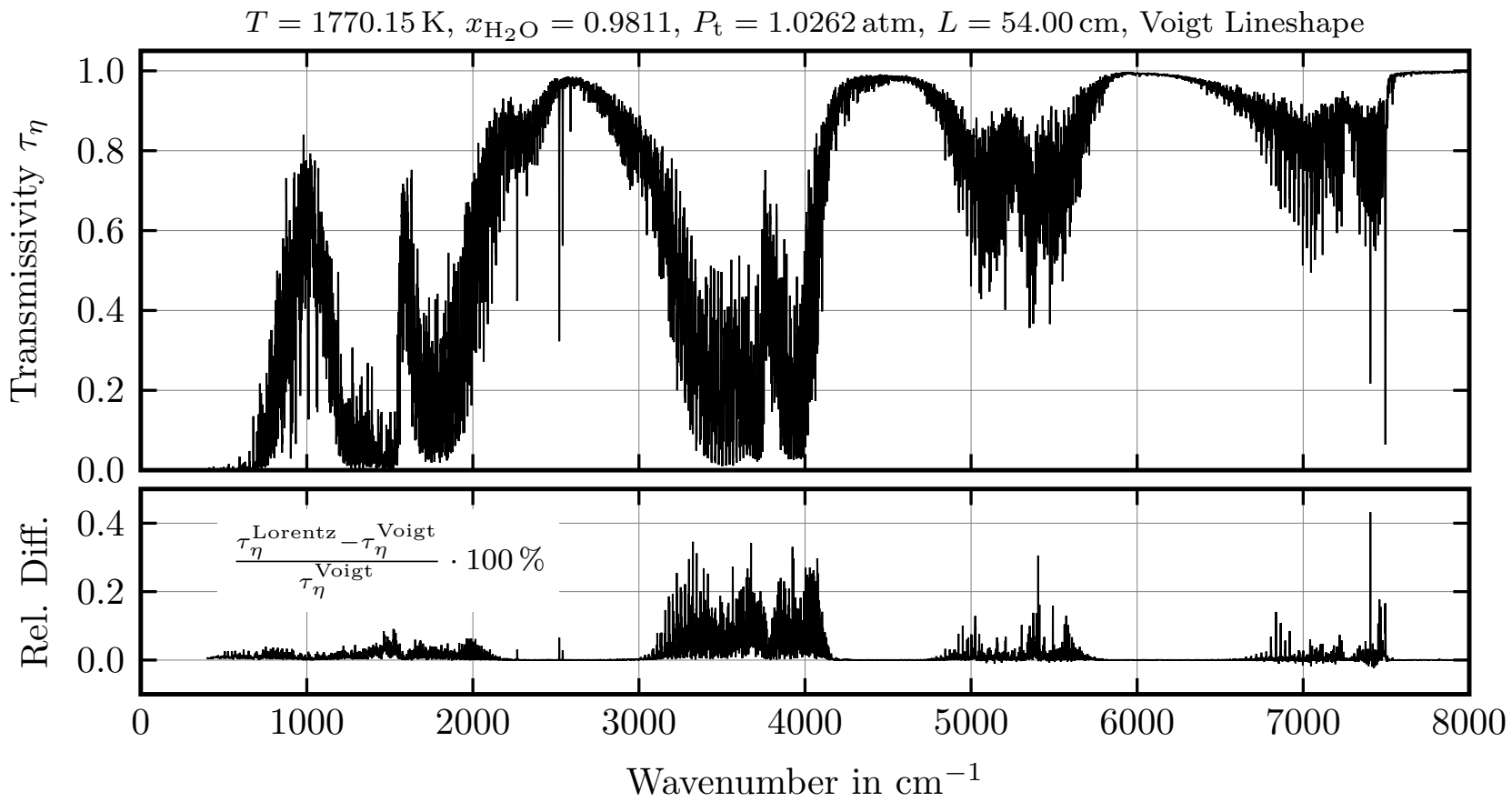
The gas cell design can be traced back to Hottel & Mangelsdorf (1935). [3]

Appendix



See also Ref. [3]

Appendix



See also Ref. [3]